GRAPHICAL ELECTROCARDIOGRAM WAVEFORMS AS PART OF AN INTEGRATED HOSPITAL SYSTEM'S PATIENT RECORD

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ABSTRACT

The U.S. Department of Veterans Affairs (VA) has an ongoing project to integrate diagnostic images into its existing text-based hospital information system. High-quality images from cardiology, pulmonary medicine, gastroenterology, endoscopy, pathology, radiology, hematology and nuclear medicine can be displayed for clinicians quickly and conveniently on workstations throughout the hospital. As a part of this endeavor, diagnostic-quality computer generated 12-lead electrocardiograms, including both median and rhythm data, can be viewed as a part of the on-line patient record of an integrated hospital information system. Now computer generated graphics can be included in the longitudinal patient record. Incorporating generated graphics and images into a text based patient record is another step towards the next generation of integrated hospital information system with multimedia patient records.

INTRODUCTION

To support its physicians in providing high-quality health care, the VA is installing and evaluating a distributed imaging system that integrates image management and communications into its existing text-based integrated hospital information system, the Decentralized Hospital Computer Program (DHCP). [1] DHCP is composed of over fifty VA developed software packages. The DHCP Medicine package provides the initial integration step for text as well as image data related to medical procedures. The package provides for the entry, editing and viewing of data for a large number of medical tests and procedures via a menu-based system. Printed reports can be produced for all procedures. Currently, the medicine package has seven modules including cardiology, pulmonary medicine, gastroenterology, hematology, pacemaker, rheumatology and generic medical procedures. Images can be captured at the DHCP imaging workstations and added to the patient record in all of these modules.[2] Previously, the electrocardiogram (ECG) report, included in the cardiology module, has been a text-based interpretation of the electrocardiogram waveforms.

The initial test site for the DHCP Integrated Imaging System is the Washington (DC) VA Medical Center, a 700-bed facility that provides acute and long-term care for the veterans of the Washington area. Approximately thirty imaging workstations are installed and in routine use, providing the ability to capture, display, store, and retrieve clinical images. The Washington VA Medical Center is the test site for the incorporation of graphical ECGs into DHCP,

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followed by the Baltimore VA Medical Center.

With full networked connectivity between magnetic and optical jukebox image servers, 80386/486-based high-resolution true color image workstations, and the DHCP hospital information system, the system has been handling various medical images for three years. The desire to include the graphical ECG waveform data in the patient record has led to the development of a graphical display extension for the DHCP Medicine Package that renders full diagnostic-quality ECG images.[3]

IMPLEMENTATION

Most vendors of electrocardiographic equipment are currently providing graphical displays for their standalone ECG systems. Due to screen and memory limitations, however, most of these displays rely heavily on subsampling the data for image display, resulting in a nondiagnostic quality image. Additionally, clinicians prefer to see the ECG in the same format that they are accustomed to seeing on paper.

The electrocardiogram signal acquisition system that is being used for this project is the Marquette Systems MUSE 5000.[4] Patient identification information along with the waveform data is saved in a compressed MS-DOS file on the Marquette system and then passed to a DHCP image server via Netware over ethernet. Files are uncompressed for use, as necessary. Uncompressed ECG data files are approximately 45k in size and compressed files can be as small as 4k.

Incorporating the graphical waveforms into the DHCP patient record once they are received from the Marquet MUSE system requires that the file header information be read and matched to a patient record. Identification of the type of file and how it should be treated is made, and a pointer to the ECG file is then assigned by a utility workstation attached to the network.

The clinician, at any imaging workstation on the network, can select a patient and view a menu of small image abstracts created from ECG waveforms, along with other types of diagnostic images collected from other areas of the hospital (x-ray, endoscopy, etc.) Upon selection of an image, procedures are invoked to generate the full diagnostic-quality 12-lead ECG at the imaging workstation.

The DHCP imaging workstation is a two-monitor system for both text and graphics display. An analog RGB monitor is used for graphics display and is driven by the Truevision AT-VISTA graphics display adapter. Graphics function calls to the AT-VISTA, written as external assembly and C routines, allow both text and graphics to be drawn on the graphics screen.[1] The ECG module of the hospital information system, which controls capture and display, is written in MUMPS.

To reproduce the ECG images in a diagnostic-quality format similar to what clinicians are accustomed to viewing, a 4096 horizontal pixel resolution was required. An 8-bit color image was used to fully display the ECG data, without subsampling. To display waveform data, in a manner that would not cause confusion to clinicians, color was used. This approach reduced memory constraints and freed additional memory to provide the 4096 horizontal pixel resolution.

Descriptive text data from the MS-DOS ECG data file (i.e., patient name, id number, date/time of exam, etc.) is read and displayed on the screen. A grid is then calibrated and drawn to the screen's addressable memory of 4096 x 468. Rhythm data from the MS-DOS ECG data file is mathematically processed as necessary, depending on the ECG-lead, and then drawn to the screen. Two colors are used to avoid viewer confusion when waveforms collide. Then median data is read from the same file, again processed as necessary, and drawn to the screen. An overall image, calibrated and identical to the diagnostic output that the clinician is accustomed to using, is now available in addressable memory for viewing. A screen-handling function then enables horizontal panning of the image at the viewer's discretion. The viewer pan across all twelve of the ECG leads, displayed at 2.5 second intervals, as well as a full 10 second segment of lead II. Following this, the median data, for all twelve leads, is displayed.

DISCUSSION

In this new age of health care reform, the importance of an effective, efficient, and complete patient record is more fully recognized. Since an electrocardiogram is an important tool in diagnosis and treatment, it is imperative that it be accessible to clinicians at any time. Including the electrocardiogram image in the automated patient record will allow clinicians to access this information faster and more efficiently.

Now, not only the physician sitting in the emergency room next to the paper scrolling from the ECG acquisition system, but also physicians in other areas of the hospital or in other areas of the country will have immediate access to ECG data. Graphical ECG data in diagnostic form can be critical and far more informative than a coded diagnostic entry in a patient record or the most detailed records that have been misplaced. Having baseline studies from previous exams immediately available for comparison can only yield more effective cardiac evaluation and treatment.

Results of the past three years use of the imaging system at the Washington VA Medical Center have shown that physicians, in contrast to the usual reluctance to perform data entry, are willing and eager to capture images that will be included in the patient record. Integration of images across specialties is important to acquiring an overall understanding of the patient. Images convey information rapidly.[5]

Currently, methods for faster image processing are under study, including the incorporation of more rapid disk i/o buffering algorithms. Further work will include integrating electrocardiograms created on other systems into DHCP and incorporating, graphically, other diagnostic studies, such as Holter monitoring. The ECG software automates an existing manual system. We will be going beyond this manual functionality by adding new data views such as the use of pattern recognition to assist in waveform comparisons and displays of selective leads over time. The ECG software will serve as a model for implementation of other graphically displayed diagnostic studies.

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